CEG4510/CEG6510

3-D Modeling and Computer Animation

Outline

1) **Introduction**
2) **Three-Dimensional Object Representations**
3) **Transformations**
4) **Interpolation techniques**
5) **Kinematic Linkages**
6) **Physically-Based Animation**
7) **Fluids**
8) **Modeling and Animating Human Figures**
9) **Special Models for Animation**

Literature (books)

Rick Parent, **Computer Animation**, Morgan Kaufman, 2008 (Second Edition)

Woo, Neider, Davis, Shreiner, **OpenGL Programming Guide**, Addison Wesley, 2000, http://www.opengl.org/documentation/red_book_1.0

Assignments

There will be three assignments and one final project:

- Camera Flight Path
- Model Animation
- Mass-Spring System
- Particle System

Assignment 1

Camera Flight Path:

Based on your PLY-renderer from Computer Graphics II, implement a camera-path in such a way that the camera flies around the object rendered. Use gluLookAt to specify the camera settings. The camera-path should follow a Bezier-spline curve. Hence, you will need to specify suitable Bezier points placed around the object. This then allows you to compute a parameterized camera-path which can be used for the animation. As the look-at point, the center of the bounding box of the object can be used. Utilize the animate feature in GLUT to increment the parameter so that the camera flies around the object and renders a new image every time the camera changes (you should check the current time so that the camera speed does not depend on the speed of the computer.)

Assignment 2

Model Animation:

Create an animation of a walking skeleton. In order to animate this model, which was downloaded from here, use blender to separate the individual parts needed for walking. Based on the inverse kinematics technique cyclic coordinate decent the system should be able to automatically control the individual components by simply specifying to put one foot in front of the other.

Assignment 3

Mass-Spring System:

Implement a mass-spring system that simulates a surface. The Bezier surface should consist of a 4x4 grid points and can be drawn using simple triangles connecting the grid points. The software should allow a user to move the grid points parallel to the image plane. Define a mass-spring system where a certain mass is assumed at the grid points and the grid points are connected via springs along the parameter lines. Once a grid point is moved, the tension in the system should relax slowly resulting in a cloth-like animation of the surface. Make sure the normals are specified correctly to ensure proper lighting.

Final Project

Particle System:

Design a particle system that incorporates collision detection. Use simple spheres to represent the particles. Start particles randomly at the top. Gravitational force pulls the particles downward into a container that has a dent in the center of its bottom. The particles can bounce off the container as well as collide with each other which may change their direction. During the simulation, your software should still allow a user to rotate, zoom, or pan.

Disclaimer

The slides are based on the slides provided by Rick Parent as additional material for the textbook.

A few slides of chapter 2 are based on the interactive introduction to OpenGL by Dave Shreiner, Ed Angle, and Vicki Shreiner.

Some material is taken from Steve Rotenberg's CSE169: Computer Animation course.

Most image and video material is from online sources, including YouTube and the author's course material.

Introduction

Computer Using a computer

Animation Moving things that can't move themselves

Techniques

"artistic" animation:	key frames & interpolation
data-driven animation:	motion capture and then mapped onto graphical objects
procedural animation:	physics- or behavioral-based computational model used to control motion

Perception

persistence of vision:	human eye retains visual imprint of an image, called positive afterimage, for a brief instant
perception of motion:	human eye perceives changing images as motion
flicker:	frequency of images needs to be high enough, otherwise the perception of continuous imagery fails; depending on lighting condition and viewing distance the minimal frequency is called critical flicker frequency

Perception

motion blur:	if an object moves too quickly the human eye will not be able to respond fast enough for the brain to distinguish sharply defined individual details
update rate:	rate at which images are shown, i.e. the image is updated/refreshed
display rate:	rate at which the display system refreshes the image
Example:	NTSC - 29.95 fps, interlaced, 640x480

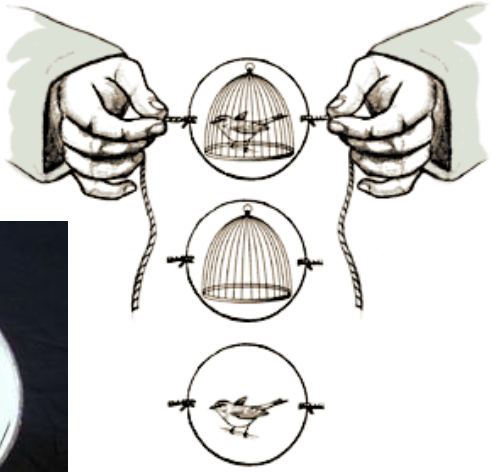
The Heritage of Animation

Early devices
Conventional animation
Disney
Stop Motion Animation

Introduction

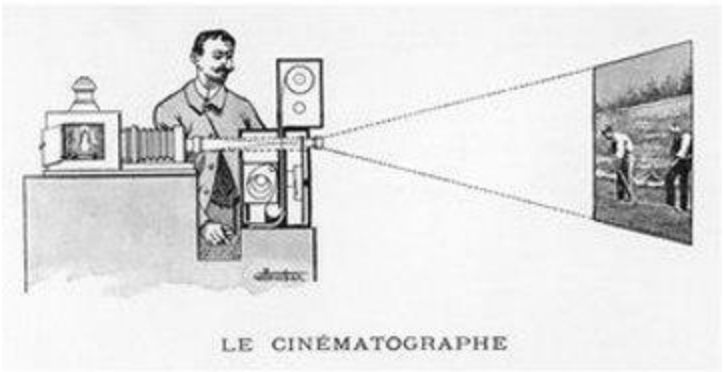
Early Devices

Flipbook
Thaumatrop
Zoetrope
Lumiere brothers
Edison: Kinetograph



Thaumatrop

Zoetrope



Cinematograph

Conventional Animation

Filming of hand-drawn, two-dimensional images

Stuart Blackton

Winsor McCay

Humorous Phases of Funny Faces (1906)
www.animationarchive.org

Introduction

Disney

Multiplane camera

Allows for parallax where objects at different “depths” can move with different speeds

Stop Motion Animation

- Modeling using puppets or clay
- Animation in separate, well-defined steps

Willis O'Brien – King Kong
Ray Harryhausen – Jason and the Argonauts
Nick Park – Wallace and Gromit
Tim Burton – Nightmare before Christmas

Principles of Animation

Basic animation principles that go back to the 9 old men of Disney:

- Illusions of Life
- Art form

- arcs
- secondary action
- ease in
- anticipation
- appeal
- in-between v. straight ahead
- Follow-through
- staging

Principles of Animation

Simulating physics:	squash and stretch
	arcs
	slow in & slow out
	solid drawing
Make it appealing:	appeal
	follow-through
	exaggeration
Effective presentation:	anticipation
	Staging
	secondary action
Production alternatives:	in-between v. straight ahead

Principles of Filmmaking

they have rules!

180 degree rule:	camera stays on same side of action
rule of thirds:	place interesting object in an image one third along the way
types of shots:	low-angle shots suggest power or dominance to the subject while high angle shots represent insignificance of subject
3-point lighting:	key light, fill light, rim light
tilt:	rotation around view direction can convey a sense of urgency, strangeness, or fear
framing:	allow enough room for motion

focus the viewer's attention to what is important in the image

Animation Production

Production->sequence->shot->frame

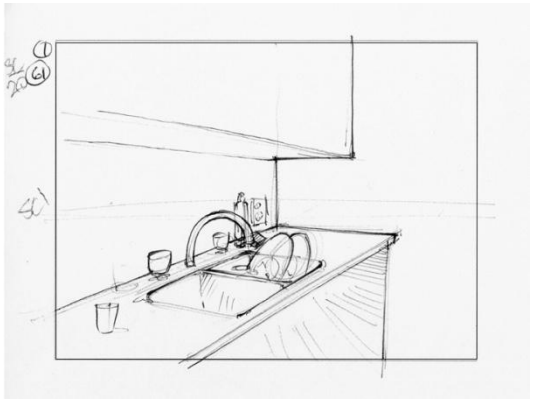
Storyboard: the proposal
Model sheet: number of drawings for each figure to ensure consistency
Animatic: storyboard with timing
Key frames & in-betweens

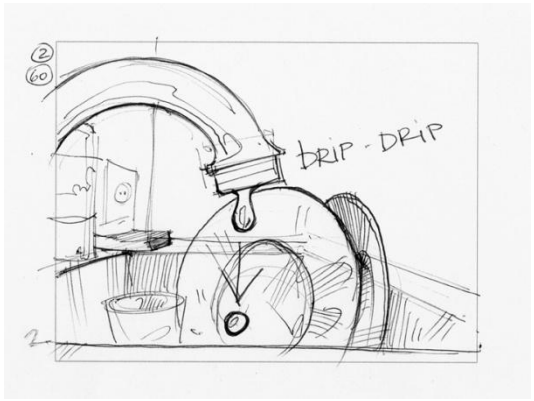
Animation Production

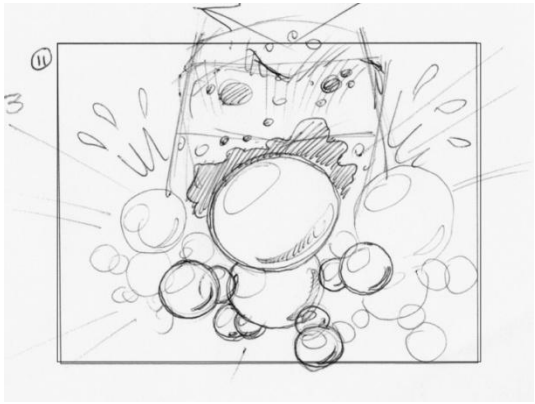
Test shot: short sequences rendered in full color as test of rendering and motion
Pencil tests: full-motion rendering of a extended sequence using low-quality images, such as pencil sketches
Inking: drawings onto celluloid
Painting: coloring in of the celluloid
Sound: voice, body, special effects, background

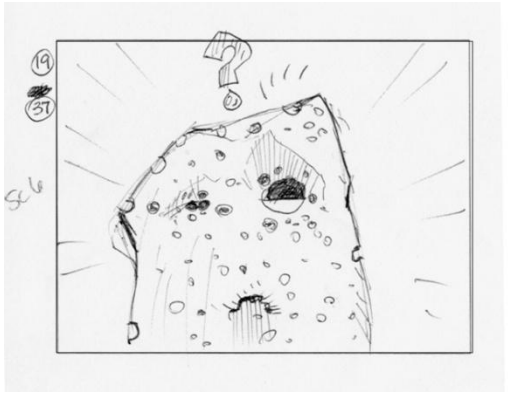
Introduction

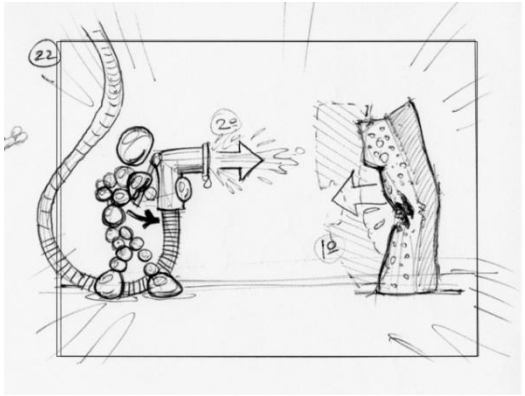
Storyboard

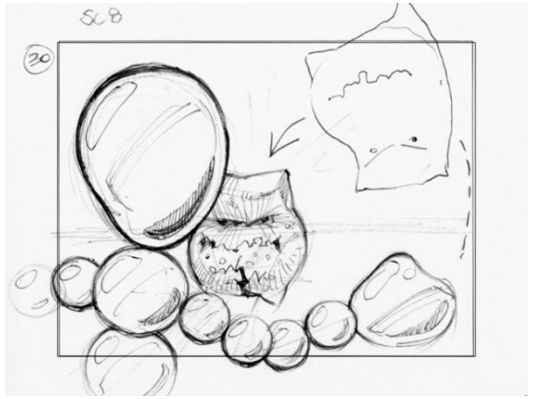












Computer Animation Production

Pencil tests - rendering controls

- shadows
- physics
- articulation
- textures
- facial animation

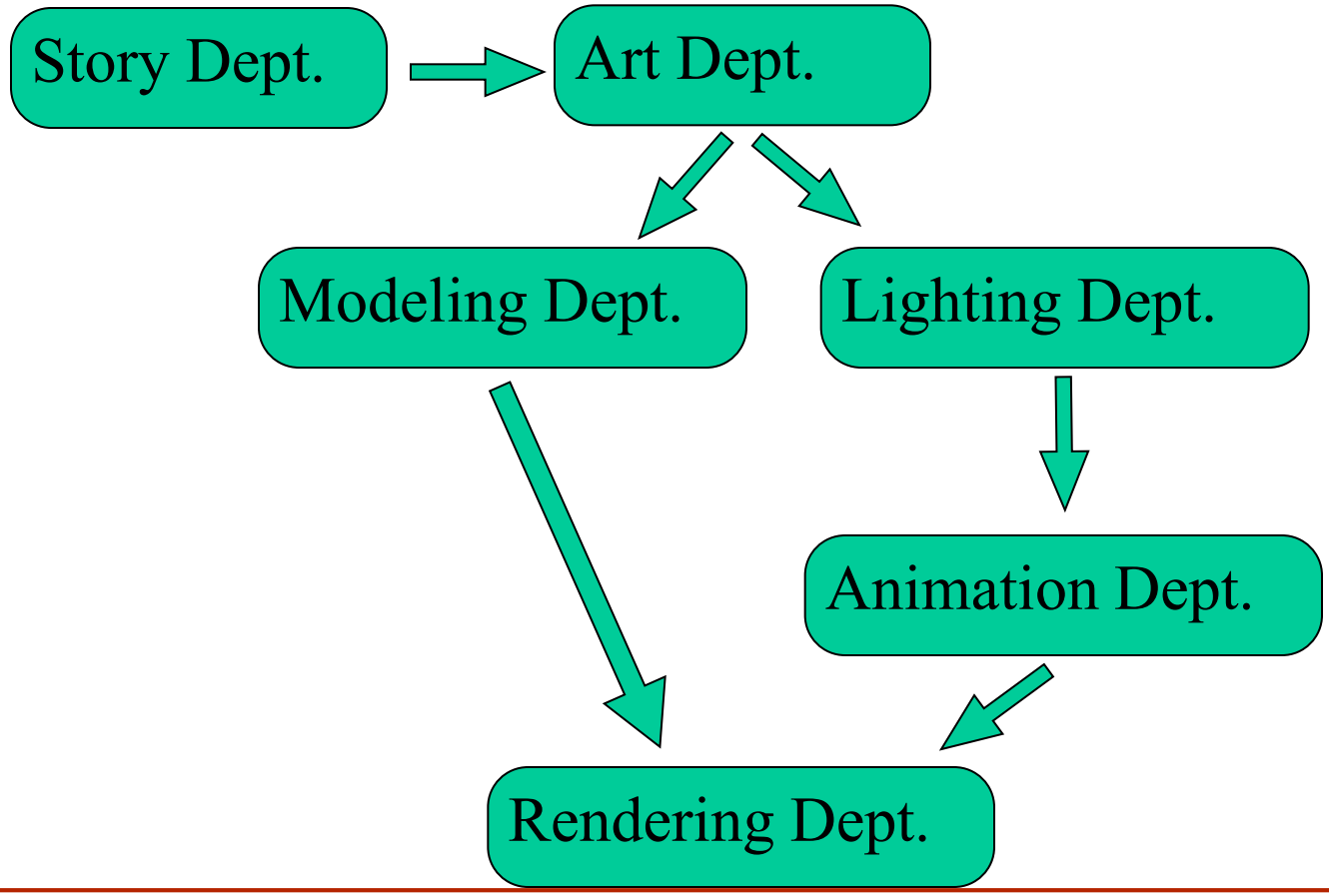
Pencil tests & Motion studies

Place holder objects
- Levels of Detail
- solids of revolution

Partial renderings
- shadows
- texture
- reflections

Interpolated movement

CA Production Tasks



Digital Media

cheap digital storage -high resolution
no degradation
digital recording process, digital display process
digital special effects

Digital Online Non-linear Editing

Digital editing
Digital video
Digital audio

History of Computer Animation

Early activity
The middle years
Animation comes of age

Early Activity

Utah - first in graphics: DoD
Evans & Sutherland, Frank Crow, Ed Catmull, Jim Blinn
CMU - Don Greenberg, Architecture
Michael Cohen, Andrew Witkin, Barr, Jessica Hodgins
Ohio State - Artistic animation, Chuck Csuri
zGrass, Dave Zeltzer, Doug Roble
U. Penn - Norm Badler - human figure animation
N.C. State - John Staudhammer,
Early hardware raster displays
N.Y.U. - Utah graduates: Ed Catmull, Alvy Ray Smith
Montreal - Daniel Thalmann & Nadia Megnenat-Thalmann

The Middle Years

Pixar - six shorts; first to win Academy Award

The Works - NYU

Young Sherlock Holmes - first CG character

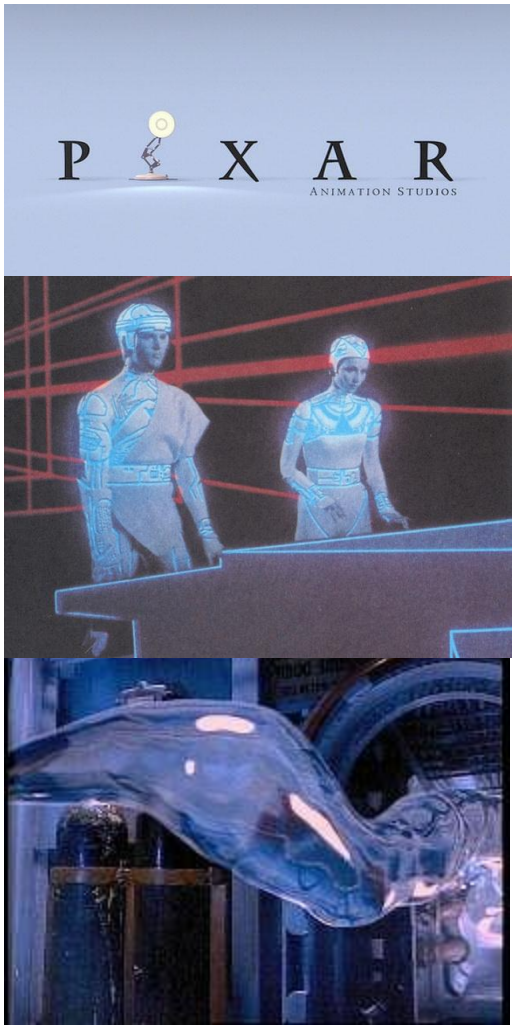
Tron - first extensive use of CG

The Last Starfighter - first synthetic space ship

Future World - first use of CG

Looker - first CG character

The Abyss - first CG blobby particle system effect



Introduction

CA comes of age!

breakthrough films

Terminator 2 - extensive use of CG effects
Jurrasic Park - first integrated CG figures
Batman Returns - first use of CG stunt double
Jumanji - first use of real CG figures
Titanic - extensive use of CG human figures
Star Wars - first major CG character
Final Fantasy - most realistic use of CG human figures

Introduction

CA comes of age!

Use of CG in traditional animation

Beauty and the Beast - CG environment (ballroom)
Tarzan - hand-drawn figures in CG environment (trees)
Prince of Egypt - CG figures in hand-drawn environment
Lion King - flocking control of wildebeest stampede

Introduction

CA comes of age!

Other notable films

Saving Private Ryan - extensive use of CG sets & doubles
LotR - extensive use of CG effects, characters